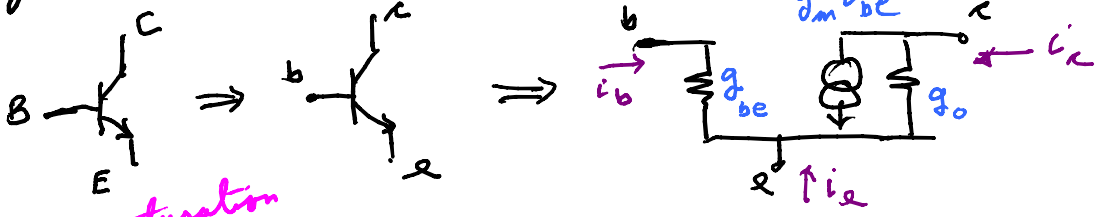
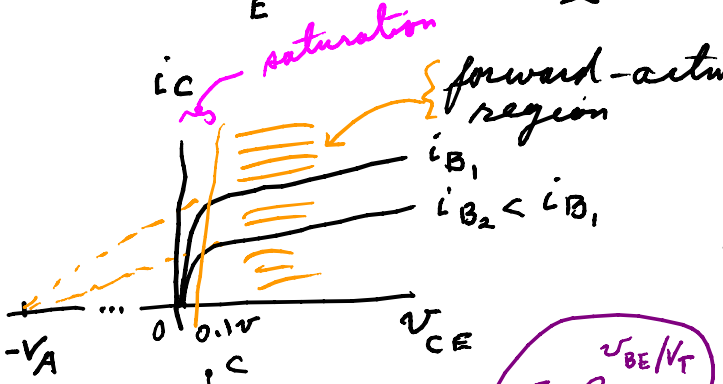
EE303
02/12/07

Rp. 443–449

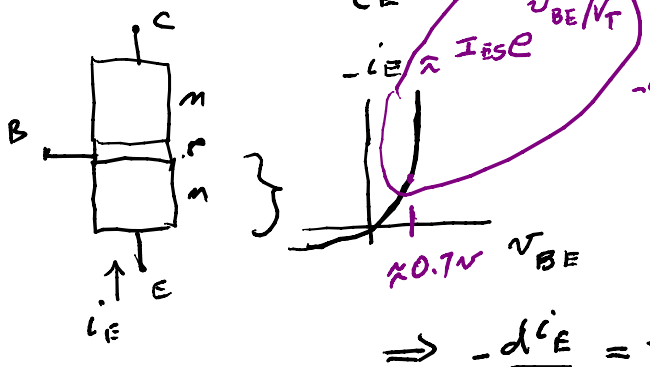
π equivalent for BJT grounded emitter, npn





= forward bias B-E
back bias C-B

for forward bias use
$V_{BE} \approx 0.7V$



$$-\frac{di_E}{dv_{BE}} = \frac{-I_E}{V_T}$$

$$i_c + i_b + i_e = 0 \Rightarrow i_c + i_b + i_e = 0$$

$$i_c = \beta \cdot i_b = \alpha(-i_e)$$

$$\Rightarrow -\frac{di_E}{dv_{BE}} = -\frac{I_E}{V_T} = \frac{1}{\alpha V_T} \cdot I_C$$

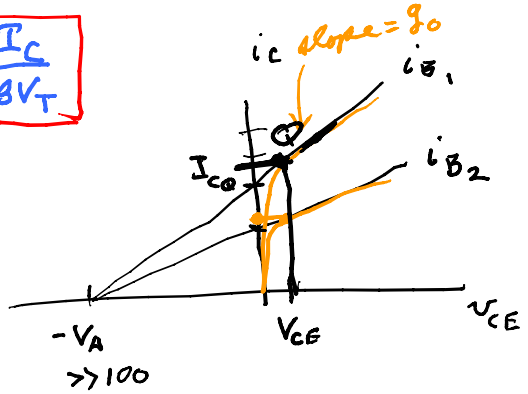
but device for the π-eq.

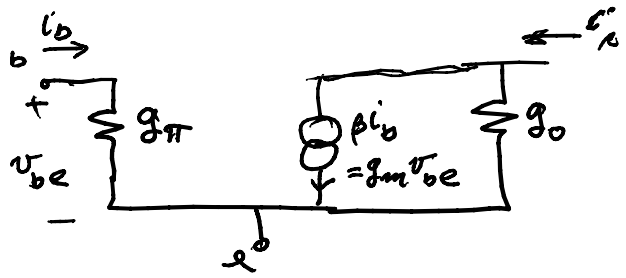
$$\frac{di_B}{dv_{BE}} = \frac{d\left(\frac{1}{\beta} i_C\right)}{dv_{BE}} = \frac{1}{\beta}\frac{di_C}{dv_{BE}} = \frac{1}{\beta}\frac{d(-\alpha i_E)}{dv_{BE}} = \frac{\alpha}{\beta}\cdot\frac{d(-i_E)}{dv_{BE}} = \frac{\alpha}{\beta}\cdot\frac{I_C}{\alpha V_T}$$

$$g_{be} \cdot v_{be} = i_b \Rightarrow \frac{i_b}{v_{be}} = g_{be} = \boxed{g_\pi = \frac{I_C}{\beta V_T}}$$

$$g_o = \left.\frac{\partial i_C}{\partial v_{CE}}\right|_Q = \frac{I_{CQ}}{V_A + V_{CE}} \approx \frac{I_{CQ}}{V_A}$$

$$= \frac{i_c}{v_{ce}}$$





$i_c = \beta i_b$

but $i_b = g_\pi v_{be}$

$\Rightarrow \beta i_b = \beta g_\pi v_{be} = i_c$ | $\Delta v_{CE} = 0$

$\Rightarrow i_c = g_m v_{be} \Rightarrow$

$g_\pi = \frac{I_C}{\beta V_T} = \frac{1}{\beta} g_m$

$g_m = \frac{I_C}{V_T}$; $g_o = \frac{I_C}{V_A}$

$g_m = \beta g_\pi = \beta \frac{I_C}{\beta V_T}$

$= \frac{I_C}{V_T}$

∴ I_C fixes the π eq. once known the transistor parameters

β, V_A ; $V_T = kT/|q|$

Hybrid π equivalent circuit: add in series "lead" resistors